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Determine Correlation between Traits and Regression of Bread Wheat Affected Different Level of Combination Chemical and Biological Fertilizer and Several Type of Application Fertilizer

Zhaleh Ahmadi*

MSc. Graduated, Department of Agronomy, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran.

RESEARCH ARTICLE

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ABSTRACT

BACKGROUND: Seed yield, as the most important quantitative characteristic, will be a result of genotype, environment and genotype-environment interaction effects.

OBJECTIVES: Current study was done to assess effect of different rate of combination fertilizer and biological fertilizer and type of application biofertilizer on effective characteristics on seed yield.

METHODS: This research was carried out via factorial experiment based on randomized complete blocks design with three replications along 2020-2021 year. The treatments included different rate of combination Nitrogen fertilizer and Biofertilizer (Fla Wheat) (a_1: 100% nitrogen with nonuse of Fla Wheat as control or N_{100}/F_0, a_2: 70% Nitrogen with Fla Wheat or N_{70}/F_1, a_3: 40% Nitrogen with Fla Wheat or N_{40}/F_1) and several methods of applying biofertilizer (Fla Wheat) (b_1: 100% Seed treatment, b_2: 100% by irrigation, b_3: 50% seed treatment with 50% by irrigation).

RESULT: According result of analysis of variance effect of different level of fertilizer combination, method of application fertilizes (instead NAR, CGR, spike length and number of spikelet per spike) and interaction effect of treatments (instead LAI, NAR, CGR, spike length, seed nitrogen content, seed protein content, number of spike per m^2, number of spikelet per spike) on all measured traits was significant. The most positive and significant correlation was observed between seed yield and biologic yield (0.992^{**}), harvest index (0.910^{**}), 1000 seed weight (0.895^{**}), number of seed per spikelet (0.771^{**}), number of spike per square meter (0.707^{**}) at 1% probability level. The traits of seed protein content (-0.680^{*}), number of seed per spike (0.662^{*}), spike length (0.653^{*}), number of spikelet per spike (0.651^{*}) and nitrogen protein content (-0.611^{*}) had correlation with the seed yield was significant at 5% probability level.

CONCLUSION: Characteristics such as of biologic yield, harvest index 1000 seed weight, number of seed per spikelet and number of spike per square meter had the most positive-direct effects on wheat seed yield can be proposal to plant breeder to more studied process such as stepwise regression and path analysis.

KEYWORDS: *Quantitative and Qualitative traits, Microbacterium, Morphology, Seed, Yield.*

***Corresponding Author:** Zhaleh Ahmadi ✉ Zh.ahmadi@gmail.com

1. BACKGROUND

Multivariate analyses are useful for characterization, evaluation and classification of plant genetic resources when a number of accessions are to be assessed for several characters of agronomic, morphological and physiological importance. Different types of multivariate analysis such as regression analysis, path analysis, principal component analysis (PCA) can be used to identify groups of genotypes that have beneficial traits for breeding and instructing the patterns of variation in genotype accession, to recognize relationships among accessions and possible gaps. Correlation coefficients describe the mutual relationships between different pairs of characters without providing the nature of cause and effect relationship of each character (Sharifi *et al*., 2020). The use of genotypic correlation helps evaluating the magnitude and direction of associations between characters facilitating the application of indirect selection, because genetic changes in a given trait may change other traits, leading to faster and larger genetic gains in plant breeding programs. Therefore, the selection for another trait may result in indirect response in the low heritable trait, provided the following conditions are satisfied: the genetic correlation between them is substantial, and the heritability of the secondary trait is greater than that of the primary trait (Ismaili *et al*., 2017). Ghalejoughi *et al*. (2013) studied regression and correlation between grain yield and related traits of corn hybrids, and revealed a positive significant correlation between grain yield and the weight of grain, stem diameter and total number of grains. The equation of regression of grain yield indicates that the effective roles of vegetative organs growth and biological yield in grain yield within this experiment. Yield improvement is a major breeding objective of most crop improvement programs (Ghobary and Abd-Allah, 2010). Correlation analysis describes the mutual relationship between different pairs of characters without providing the nature of cause and effect relationship of each character. Significant positive correlations were detected between faba bean seed yield and each of number of pods per plant, number of seeds per plant, seed weight per plant and biological yield (Alghamd, 2007). Seed yield, as the most important quantitative characteristic, will be a result of genotype, environment and genotype-environment interaction effects (Marjanovic-Jeromela *et al*., 2009). Soltani Howyzeh *et al*. (2018) by compare seventhin spring canola reported the correlation coefficients among the seed yield and 1000-seed weight, number of seed per pod, harvest index and days to maturity were positive and significant. Results of stepwise regression analysis revealed that 1000-seed weight, number of pods per plant and days to maturity had significantly effects on seed yield. The increase of biologic yield and its direct relation with seed yield show the relations between photosynthesis efficiency of plant and seed yield, therefore genotypes which have gained more profit of production factor according to growth conditions and they keep more photo-

synthesis materials in their sinks, have more efficiency. This status was in conformity with the results of some other researchers (Mardin, 2017; Tian, 2017). The significant and positive correlation between harvest index and seed yield indicate efficiency and kind of photosynthesis materials distribution in different parts of plant, especially in seed. Results of Xianc (2018) verify the mentioned issues.

2. OBJECTIVES

Current study was done to associations between yield components and other crop traits with seed yield and discusses the interrelationships among the examined traits.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This research was carried out to evaluate Nitrogen fertilizer and Biofertilizer (Fla Wheat) on growth indices of Wheat crop via factorial experiment based on randomized complete blocks design with three replications along 2020-2021 year. Place of research was located in Hamidiyeh city at longitude 48°40'E and latitude 36°31'N in Khuzestan province (Southwest of Iran). The treatments included different rate of combination Nitrogen fertilizer and Biofertilizer (Fla Wheat) (a_1: 100% nitrogen with nonuse of Fla Wheat as control or N_{100}/F_0, a_2: 70% Nitrogen with Fla Wheat or N_{70}/F_1, a_3: 40% Nitrogen with Fla Wheat or N_{40}/F_1) and several methods of applying biofertilizer (Fla Wheat) (b_1: 100% Seed treatment, b_2: 100% by irrigation, b_3: 50% seed treatment with 50% by irrigation). This experiment had 36 plots. Each plot consisted of 9 lines with a distance of 20 cm and 5 meters length. Result of soil test of studied ground was mentioned in table 1.

Table 1. Physical and chemical properties of studied field

Soil texture	Clay (%)	Silt (%)	Sand (%)	K (ppm)	P (ppm)	N (%)	OC (%)	pH	EC ($ds.m^{-1}$)	SP (%)
Clay loam	52	27	21	168	9.1	0.039	0.6	7.2	3.5	48

3.2. Farm Management

According to the fertilizer recommendation of the soil and water department of the Agricultural and Natural Resources Research Center of Khuzestan Province, the rate of application urea fertilizer was 300 $kg.ha^{-1}$ (equivalent to 138 $kg.ha^{-1}$ pure nitrogen). Phosphorus fertilizer from triple superphosphate source at the rate of 90 $kg.ha^{-1}$ and potash fertilizer from potassium sulfate source at the rate of 50 $kg.ha^{-1}$ were applied as a base before planting. 1/3 of nitrogen fertilizer was applied as a base and the remaining 2/3 at tillering and steam elongation stage. Distilled water was used instead of Fla Wheat in the control treatment. It should be noted that according to the manufacturer's recommendation, for every 100 kg of seeds, one liter of Fla Wheat biofertilizer was used as seed treatment. Place the seeds in the shade on nylon or a clean surface and sprinkle

the bio-inoculum gradually on the seeds after shaking and mix well so that all of them are evenly impregnated with fertilizer. Then, in the shortest time after drying the seeds in the shade, planting was done. In the method of inoculation with irrigation in two shifts (each stage in the amount of one liter per hectare and at intervals of 40 days) Fla Wheat biofertilizer was applied with irrigation water. The first stage was at the beginning of the stem and the second stage was at the time of pollination. Fla Wheat biofertilizer contains *Microbacterium sp*. This biofertilizer increases wheat yield in dry and irrigated conditions due to its growth-promoting bacteria (10^7-10^8 CFU per gram) and production of natural growth hormones.

3.3. Measured Traits

In order to determine the yield two planting lines from each plot harvested and after the removal of marginal effect were carried to the laboratory and were placed in the oven at 75°C for 48 hours and after ensuring that the samples were completely dry, they were weighed and finally the total dry weight was measured. By measuring three factors including leaf area, leaf dry weight and total dry weight, the physiological parameters of growth including LAI, NAR, CGR and RGR were obtained using the following equations. To determine the leaf area of the linear relationship S= K. L.W was used in which S, L and W were the leaf area, L and W respectively, the maximum length and width of each leaf and K= 0.75 correction coefficient. The leaf area index was calculated from leaf area ratio to ground level. Crop growth rate, net assimilation rate and relative growth rate were measured according fallowing formula (Buttery, 1970; Enyi, 1962):

Equ.1. CGR ($g.m^{-2}.day^{-1}$) = TDM_2-TDM_1/T_2-T_1

TDM_1= Primary dry weight (g), TDM_2= Secondary dry weight (g)

T_1= initial sampling time, T_2= Secondary sampling time

Equ.2. NAR ($g.m^{-2}.day^{-1}$) = CGR* $LnLA_2$-$LnLA_1/LA_2$-LA_1

CGR = Growth rate in grams per day per square meter

LA_1 = Initial leaf area, LA_2 = Secondary leaf area

Equ.3. RGR ($g.g^{-1}.day^{-1}$) = [Ln (TDM_2) – Ln (TDM_1)]/T_2-T_1

RGR= relative growth rate in gram per gram per day

In order to determine the seed yield and its components, the two side rows and half a meter of the beginning and end of each plot were eliminated as the marginal effects and finally the ultimate samples were taken from an area of 1 m^2. In order to determine the number of spikes per area unit, the spikes were taken from an area of 1 m^2 of then three middle lines of each plot after considering half a meter of beginning and end of each line as the margin and after counting the spikes their mean was considered as the number of spikes per area unit. As many as 10 spikes were randomly selected from the middle lines of each plot and the number of seeds was counted carefully and their mean was recorded. Two 500-seed samples were randomly selected from the produced seeds by each plot and if the weight difference of the two samples was less

than 5%, the total weight of the two samples was considered as weight of 1000-seed. After full maturity of the seeds, the spikes were taken from the 3 middle lines of each plot in an area of 1 m^2 and the seed yield of each plot with moisture of 14% was calculated per area unit and then was recorded. Harvest index (HI) was calculated according to formula of Gardner *et al*. (1985) as follows: **Equ.1.** HI= (Seed yield/Biologic yield) ×100.

10 crops were randomly selected from the middle lines of each plot and the plant height and spike length was counted carefully and their mean was recorded. After full maturity of the seeds, the spikes were taken from the 3 middle lines of each plot in an area of 1 m^2 and the seed yield of each plot with moisture of 14% was calculated per area unit and then was recorded. To measure the seed nitrogen content and straw nitrogen content the Kjeldahl method was used. So, to calculate the seed protein content the following formula was used (Bremner *et al*., 1983):

Equ.1. Seed protein content (%)= Nitrogen percentage × 5.8.

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done via SAS (Ver.8) software and Duncan multiple range test at 5% probability level. For identifying correlation coefficients and regression analysis, Minitab (ver.15) software was used.

4. RESULT AND DISCUSSION

4.1. Analysis of variance

4.1.1. *Total Dry Matter (TDM)*

According result of analysis of variance effect of Fertilizer combination and method of application fertilize on total dry matter was significant at 1% probability level, also interaction effect of treatments was significant at 5% probability level along all growth stages (Table 2).

Table 2. Result of analysis of variance effect of treatment on TDM and LAI

S.O.V	df	TDM			LAI		
		Booting	Anthesis	Grain filing	Booting	Anthesis	Grain filing
Replication	2	520^{ns}	618^{ns}	643^{ns}	0.01249^{*}	0.00968^{*}	0.001526^{ns}
Fertilizer combination (F)	2	568552^{**}	651134^{**}	631352^{**}	0.68295^{*}	0.67954^{*}	0.242626^{*}
Method of application fertilize (M)	2	13520^{**}	15323^{**}	14899^{**}	0.00538^{*}	0.00614^{*}	0.006181^{*}
F×M	4	1847^{*}	2197^{*}	2075^{*}	0.00055^{ns}	0.00077^{ns}	0.000504^{ns}
Error	16	562	488	477	0.00040	0.00050	0.000722
CV (%)	-	18.8	17.59	17.72	6.59	5.23	6.10

$^{ns, *}$ and **: no significant, significant at 5% and 1% of probability level, respectively.

4.1.2. *Leaf area index* (*LAI*)

Result of analysis of variance revealed effect of fertilizer combination and method of application fertilize on leaf area index was significant at 5% probability level, but interaction effect of treatments was not significant along all growth stages (Table 2).

4.1.3. *Net assimilation rate* (*NAR*)

Result of analysis of variance showed effect of fertilizer combination on net assimilation rate was significant at 5% probability level, but effect of method of application fertilize and interaction effect of treatments was not significant along all growth stages (Table 3).

Table 3. Result of analysis of variance effect of treatments on CGR and NAR along booting until anthesis stage

S.O.V	df	NAR	CGR
Replication	2	0.006293^{ns}	0.0097^{ns}
Fertilizer combination (F)	2	0.061693*	7.0263*
Method of application fertilizer (M)	2	0.003804^{ns}	0.1457^{ns}
F×M	4	0.002459^{ns}	0.0555^{ns}
Error	16	0.002976	0.0528
CV (%)	-	4.35	9.51

$^{ns, *}$ and **: no significant, significant at 5% and 1% of probability level, respectively.

4.1.4. *Crop growth rate* (*CGR*)

According result of analysis of variance effect of fertilizer combination on crop growth rate was significant at 5% probability level, but effect of method of application fertilize and interaction effect of treatments was not significant along all growth stages (Table 3).

4.1.5. *Plant height*

According result of analysis of variance effect of fertilizer combination, method of application fertilize and interaction effect of treatments on plant height was significant at 1% and 5% probability level, respectively (Table 4).

4.1.6. *Spike length* (*SL*)

Result of analysis of variance revealed effect of fertilizer combination on spike length was significant at 5% probability level but effect of method of application fertilize and interaction effect of treatments was not significant (Table 4).

4.1.7. *Seed nitrogen content* (*SNC*)

Result of analysis of variance showed effect of fertilizer combination and method of application fertilize on seed nitrogen content was significant at 1% and 5% probability level, respectively but interaction effect of treatments was not significant (Table 4).

4.1.8. *Seed protein content (SPC)*

According result of analysis of variance showed effect of fertilizer combination and method of application fertilize on seed protein content was significant at 1% and 5% probability level, respectively but interaction effect of treatments was not significant (Table 4).

4.1.9. *Seed yield*

Result of analysis of variance showed effect of fertilizer combination and method of application fertilize on seed yield was significant at 1% probability level, also interaction effect of treatments was significant at 5% probability level (Table 5).

Table 4. Result of analysis of variance effect of treatment on plant height, spike length, seed nitrogen content and seed protein content

S.O.V	df	Plant height	Spike length	Seed nitrogen content	Seed protein content
Replication	2	41.95**	1.1135**	0.03714**	1.448**
Fertilizer combination (F)	2	821.61**	45.8136**	1.83034**	71.453**
Method of application fertilize (M)	2	25.77**	0.5881^{ns}	0.02849*	1.112*
F×M	4	5.10*	0.0953^{ns}	0.00329^{ns}	0.131^{ns}
Error	16	1.54	0.1686	0.00474	0.185
CV (%)	-	11.06	20.45	13.14	14.23

$^{ns, *\text{ and }**}$: no significant, significant at 5% and 1% of probability level, respectively.

4.1.10. *Biologic yield*

Result of analysis of variance revealed effect of fertilizer combination, method of application fertilize and interaction effect of treatments on biologic yield was significant at 1% and 5% probability level, respectively (Table 5).

4.1.11. *Harvest index*

According result of analysis of variance showed effect of fertilizer combination, method of application fertilize and interaction effect of treatments on harvest index was significant at 1% and 5% probability level, respectively (Table 5).

4.1.12. *Number of spike per m^2*

Result of analysis of variance showed effect of fertilizer combination and method of application fertilize on number of spike per m^2 was significant at 1% probability level, but interaction effect of treatments was not significant (Table 5).

4.1.13. *Number of spikelet per spike*

Result of analysis of variance revealed effect of fertilizer combination on number of spikelet per spike was significant at 1% probability level but effect of method of application fertilize and interaction effect of treatments was not significant (Table 5).

4.1.14. *Number of seed per spikelet*

According result of analysis of variance showed effect of fertilizer combination, method of application fertilize and interaction effect of treatments on number of seed per spikelet was significant at 1% and 5% probability level, respectively (Table 5).

Table 5. Result of analysis of variance effect of treatment on seed yield, its components, biologic yield and harvest index

S.O.V	df	Seed yield	Biologic yield	Harvest index	No. spike per m^2
Replication	2	2421*	643^{ns}	11.57**	189.22**
Fertilizer combination (F)	2	404948**	631352**	760.86**	3782.87**
Method of application fertilize (M)	2	22273**	14899**	74.10**	93.30**
F×M	4	1644*	2075*	4.69*	17.67^{ns}
Error	16	435	477	0.46	8.56
CV (%)	-	7.04	17.72	21.67	4.87

ns, * and **: no significant, significant at 5% and 1% of probability level, respectively.

Continue table 5.

S.O.V	df	No. spikelet per spike	No. seed per spikelet	No. seed per spike	1000-seed weight
Replication	2	0.8686**	0.00174^{ns}	1.66^{ns}	5.303**
Fertilizer combination (F)	2	20.1142**	0.93774**	595.40**	300.457**
Method of application fertilize (M)	2	0.2417^{ns}	0.09508**	35.53**	15.282**
F×M	4	0.0365^{ns}	0.01172*	4.50*	1.805*
Error	16	0.0368	0.00306	1.04	0.531
CV (%)	-	7.69	15.11	21.85	12.64

ns, * and **: no significant, significant at 5% and 1% of probability level, respectively.

4.1.15. *Number of seed per spike*

Result of analysis of variance revealed effect of fertilizer combination, method of application fertilize and interaction effect of treatments on number of seed per spike was significant at 1% and 5% probability level, respectively (Table 5).

4.1.16. *1000-seed weight*

According result of analysis of variance showed effect of fertilizer combination, method of application fertilize and interaction effect of treatments on 1000-seed weight was significant at 1% and 5% probability level, respectively (Table 5).

4.2. Correlation between traits

Al-Salim *et al*. (2017) reported all studied traits except grain weight were highly significantly correlated with grain yield and about 35% of variation in grain yield could be explained by the level of nitrogen fertilizer. Also the traits of plant height and dry and green fodder weight were the major contributors towards grain yield since these traits explained (57, 52, 50)% respectively of the variation of grain yield.

Which might be a good traits for breeders to develop high yielding cultivars in sorghum, followed by stem diameter and grain number then leaf area index. Simple correlation coefficients between traits these coefficients were estimated according to Pearson coefficient (Table 6). The most positive and significant correlation was observed between seed yield and biologic yield (0.992^{**}), harvest index (0.910^{**}), 1000 seed weight (0.895^{**}), number of seed per spikelet (0.771^{**}), number of spike per square meter (0.707^{**}) at 1% probability level. The traits of seed protein content (-0.680^{*}), number of seed per spike (0.662^{*}), spike length (0.653^{*}), number of spikelet per spike (0.651^{*}) and nitrogen protein content (-0.611^{*}) had correlation with the seed yield was significant at 5% probability level (Table 6).

Table 6. Correlation between studied traits

Traits	1	2	3	4	5	6	7	8	9	10	11
2	-0.551^{*}										
3	-0.526^{*}	-0.599^{*}									
4	0.661^{*}	0.588^{*}	0.521^{*}								
5	0.621^{*}	0.551^{*}	0.570^{*}	0.660^{*}							
6	0.651^{*}	0.771^{**}	0.662^{*}	0.707^{**}	0.895^{**}						
7	0.622^{*}	0.795^{**}	0.666^{*}	0.799^{**}	0.882^{**}	0.992^{**}					
8	0.669^{*}	0.501^{*}	0.511^{*}	0.795^{**}	0.711^{**}	0.910^{**}	0.921^{**}				
9	0.555^{*}	0.522^{*}	0.596^{*}	0.555^{*}	0.500^{*}	0.653^{*}	0.551^{*}	0.553^{*}			
10	0.426^{ns}	0.491^{ns}	0.336^{ns}	0.441^{ns}	0.481^{ns}	0.490^{ns}	0.501^{*}	0.551^{*}	0.444^{ns}		
11	0.332^{ns}	0.331^{ns}	0.211^{ns}	0.332^{ns}	0.432^{ns}	-0.680^{*}	0.312^{ns}	0.112^{ns}	0.331^{ns}	0.319^{ns}	
12	0.319^{ns}	0.226^{ns}	0.444^{ns}	0.299^{ns}	0.399^{ns}	-0.611^{*}	0.451^{ns}	0.221^{ns}	0.285^{ns}	0.321^{ns}	0.856^{**}

$^{ns, *}$ and **: no significant, significant at 5% and 1% of probability level, respectively.

1: Number of spikelet per spike, **2**: Number of seed per spikelet, **3**: Number of seed per spike, **4**: Number of spike per square meter, **5**: 1000 seed weight, **6**: seed yield, **7**: biologic yield, **8**: Harvest index, **9**: spike length, **10**: Plant height, **11**: Seed protein content, **12**: Nitrogen protein content.

Some researchers reported the increase of nitrogen causes a significant increase of the number of tillers per plant and fertilized tillers, leaves surface and durability of flag leaf, biological yield, number of spike per square meter and number of seeds per spike and the positive and significant effects of these traits on the seed yield, also a positive correlation between the number of seeds per spikelet and the number of spikelet per spike with the seed yield (Ehdaie and Waines, 2001; Kumar *et al*., 2001). Tadesse *et al*. (2011) indicated number of pods per plants, number of seeds per pod, thousand seed weight and plant height had significant association with seed yield per plot. The seed yield per plant exhibited positive and significant correlation with clusters per plant, pod length, plant height, branches per plant, pods per plant and hundred seed weight (Badolay *et al*., 2009). Ulukan *et al*. (2003) also found positive and significant relationships between biological yield and plant height and grain number per pod.

4.3. *Regression relationship*

In Stepwise regression analysis, seed yield was considered as a dependent variable, while other traits were considered as independent variables (Shiapchan, 2012). Quantification of plant characteristics associated with yield increase is important in crop breeding programs. Regression models can be used for this purpose (Jafarnodeh *et al.,* 2017).

Equ.3. Y= -1321 + 12.1 NStPS + 31.4 NSPSt + 62.7 NSPP+14.1 NSPSq + 29.5 SW + 2.99 SY+ 4.12 BY + 7.11HI+ 3.02 SL + 65 PH + 74 SPC + 2.98 NPC.

NStPS: Number of spikelet per spike, **NSPSt**: Number of seed per spikelet, **NSPP**: Number of seed per spike, **NSPSq**: Number of spike per square meter, **SW**: 1000 seed weight, **SY**: seed yield, **BY**: biologic yield, **HI**: Harvest index, **SL**: spike length, **PH**: Plant height, **SPC**: Seed protein content, **NPC**: Nitrogen protein content.

5. CONCLUSION

According to the results of this research, characteristics such as of biologic yield, harvest index 1000 seed weight, number of seed per spikelet and number of spike per square meter had the most positive-direct effects on wheat seed yield can be proposal to plant breeder to more studied process such as stepwise regression and path analysis.

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FOOTNOTES

CONFLICT OF INTEREST: Author declared no conflict of interest.

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